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Impacts of the changing summer thermal land-sea contrast on the northern hemisphere planetary circulation

Agostino N Meroni[1], Fabio D'Andrea[2], and Claudia Pasquero[1,3]
[1]Department of Earth and Environmental Sciences, University of Milano-Bicocca, Milan, Italy (agostino.meroni@unimib.it)
[2]Laboratoire de Météorologie Dynamique/IPSL, École Normale Supérieure, PSL Research University, Sorbonne Université, École Polytechnique, IP Paris, CNRS, Paris, France
[3]Istituto di Scienze dell'Atmosfera e del Clima, Consiglio Nazionale delle Ricerche, Turin, Italy

The zonal inhomogeneities of the land surface are known to strongly modulate the large-scale atmospheric circulation, especially in the northern hemisphere. This is related both to the mechanical forcing induced by high orography and to the thermal contrast between water and land. In a warming world, it is known that such a thermal contrast is changing but its impacts on the large-scale atmospheric circulation are poorly constrained. Recently, it has been shown that a reduced winter thermal land-sea contrast is projected to reduce the amplitude of planetary waves, with a predominant control of the Asian-Pacific land-sea contrast at the global scale.

Goal of the present study is to investigate the impacts of an enhanced summer thermal land-sea contrast on the planetary circulation. In particular, the role of soil moisture in modulating such contrast is considered with special attention. In fact, despite the importance of the land-atmosphere coupling mechanisms, that involve feedbacks with atmospheric circulation, clouds, precipitation and surface fluxes, there are still fundamental gaps in their understanding. These gaps result in an incorrect representation of the global hydrological cycle in CMIP6 models. For example, CMIP6 models are characterized by large biases in the water vapor trend representation in arid and semi-arid regions, which might be related to a poor representation of soil moisture and its impacts on the overlying and downstream atmospheric dynamics.

By analyzing the CMIP6 model spread in soil moisture, surface air temperature and upper-tropospheric geopotential height, we aim to quantify the variability of the planetary circulation in a range of realistic soil moisture configurations. Climate data records of satellite products of surface soil moisture can also be used to constrain the soil moisture variability observed in the last decades. In the second part of the project, numerical simulations with an Earth Model of Intermediate Complexity will shed light on the link between soil moisture distribution, land-sea summer contrast and planetary circulation.